

STACE CROSS EX 2

The Lineman's and Cableman's Handbook

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(Deceased)

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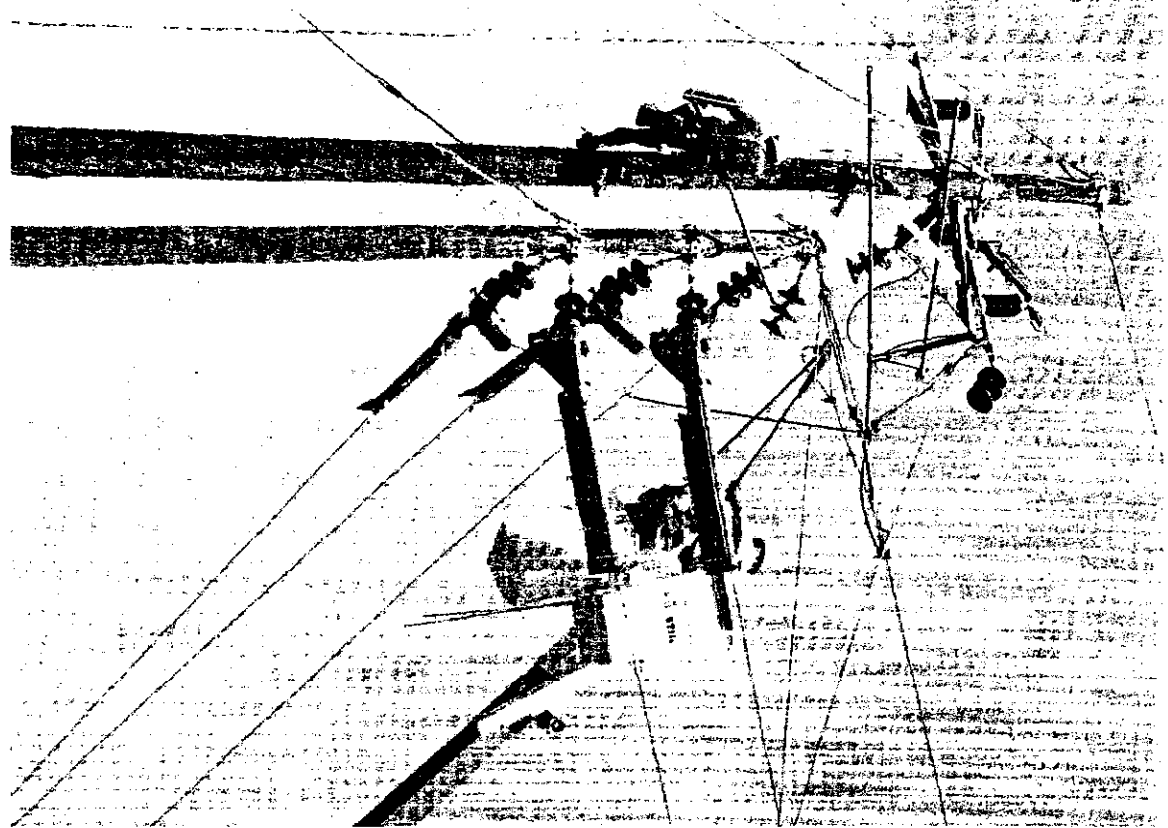
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men transferring conductors on vertical corner pole to switch on new pole. Work is being completed
a-line tools from pole and bucket truck. Cover-up material is being used to provide protection from
ed conductors. (Courtesy A. B. Chance Co.)

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Contents

Preface vii

Acknowledgments ix

Introduction xi

Section 1 Elementary Electrical Principles 1-1

Section 2 Electric System 2-1

Section 3 Substations 3-1

Section 4 Transmission Circuits 4-1

Section 5 Distribution Circuits 5-1

Section 6 Construction Specifications 6-1

Section 7 Wood-Pole Structures 7-1

Section 8 Aluminum, Concrete, Fiberglass, and Steel Structures 8-1

Section 9 Locating and Staking Line 9-1

Section 10 Unloading, Framing and Hauling Wood Poles 10-1

Section 11 Erecting and Setting Poles 11-1

Section 12 Guying Poles 12-1

Section 13 Insulators 13-1

Section 14 Line Conductors 14-1

Section 15 Distribution Transformers 15-1

Section 16 Lightning Protection 16-1

Section 17 Fuses 17-1

Section 18 Switches 18-1

Section 19 Voltage Regulators 19-1

Section 20 Transmission Tower Erection 20-1

Section 21 Stringing Line Conductors 21-1

Section 22 Sagging Line Conductors 22-1

Section 23 Joining Line Conductors 23-1

Section 24 Live-Line Maintenance with Hot-Line Tools 24-1

Section 25 Live-Line Maintenance from Insulated Aerial

Platforms 25-1

Section 26 Grounding 26-1

Section 27 Protective Grounds 27-1

Section 28 Street Lighting 28-1

Section 29 Underground System 29-1

Section 30 Laying Conduit 30-1

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Section 31	Manhole Construction	31-1
Section 32	Pulling Cable	32-1
Section 33	Splicing Cable	33-1
Section 34	Underground Residential Distribution	34-1
Section 35	Tree Trimming	35-1
Section 36	Distribution Transformer Installation	36-1
Section 37	Electrical Drawing Symbols	37-1
Section 38	Single-line Diagrams	38-1
Section 39	Schematic Diagrams	39-1
Section 40	Voltage Regulation	40-1
Section 41	Electrical Formulas and Calculations	41-1
Section 42	Definition of Electrical Terms	42-1
Section 43	Rope, Knots, Splices and Gear	43-1
Section 44	Use and Care of Pole Climbing Equipment	44-1
Section 45	Protective Equipment	45-1
Section 46	Safety Rules	46-1
Section 47	Resuscitation	47-1
Section 48	Heart-Lung Resuscitation	48-1
Section 49	Pole-Top and Bucket Truck Rescue	49-1
Section 50	Self-Testing Questions and Exercises	50-1
Index follows Section 50		

Preface

This Handbook is written expressly for the apprentice, the lineman, the cableman, the foreman, the supervisor, and other employees of transmission and distribution departments. It is primarily intended to be used as a home-study book to supplement daily work experiences. Of the 50 sections in the Handbook, 12 sections are devoted to a general understanding of electricity, electrical terms, and electric power systems; 30 sections are devoted to the actual construction of overhead and underground distribution and transmission lines and to maintenance procedures; and although all the material has a relationship to safety, 7 sections are specifically devoted to that subject. The final section is intended for the reader's self-examination of the information presented.

The following 10 sections are new in this edition: Section 3, Substations; Section 4, Transmission Circuits; Section 6, Construction Specifications; Section 7, Wood-Pole Structures; Section 8, Aluminum, Concrete, Fiberglass, and Steel Structures; Section 13, Insulators; Section 14, Line Conductors; Section 26, Grounding; Section 27, Protective Grounds; and Section 40, Voltage Regulation.

A special effort was made to present all discussions clearly and in simple language; in fact, a reading knowledge of the English language is all that is required to understand the book. As in former editions, a large number of illustrations showing the various steps in the construction and maintenance process are provided to assist the reader in better understanding the text; the illustrations appearing in the Handbook should be considered as much a part of the book as the words themselves. Illustrations bring out many details that would require many additional words to express. Many of the photographs were taken specifically for use in this edition. They therefore portray the latest practices in use today by some of the foremost electric utility companies in this country.

Methods of transmission-, distribution-, and rural-line construction have become quite standardized since the first edition of this Handbook was published in 1928. The construction procedures described and illustrated are therefore in most instances representative of general practice. While each operating company has its own standards of construction which its linemen and cablemen must adhere to, the procedures described explain why things are done in a given way. Such basic knowledge should be helpful to the lineman or cableman who is interested in learning the whys and wherefores of doing things one way or another.

Safety is again emphasized throughout the book. Of course, understanding the principles involved in any operation and knowing the reasons for doing things a given way are the best aids to safety. Nevertheless, the opinion has become quite firmly established that a man is not a good lineman unless he does his work safely. It therefore behooves those engaged in electrical work to become familiar with the safety rules and the precautions applicable to their trade and to make their observance an inseparable part of their working habits.

Emphasis is also placed on the National Electrical Safety Code, the National Power Survey, OSHA Regulations, ANSI Standards, and ASTM Standards. The important requirements of the code are reprinted and incorporated in the text where corresponding topics are discussed.

In this way the lineman becomes acquainted with the minimum construction requirements that will ensure safety to the public and to the lineman. If more code information is desired, a copy of the *National Electrical Safety Code* ANSI C2, can be secured for a charge from the Institute of Electrical and Electronics Engineers, Inc., 345 East 47th Street, New York, NY 10017.

The *National Electrical Code®* details the rules and regulations for electrical installations except those under the control of an electric utility. It excludes any indoor facility used and controlled exclusively by a utility for all phases from generation through distribution of electricity and for communication and metering, as well as outdoor facilities on a utility's own or a leased site or on public or private (by established rights) property.

Reference material includes *Standard Handbook for Electrical Engineers*, edited by Donald G. Fink and H. Wayne Beatty, and published by McGraw-Hill Book Company; Edison Electric Institute Publications; *Underground Power Transmission* by Arthur D. Little, Inc., for the Electric Power Research Council; *Electric Power Transmission and Environment*, published by the

Section 35

Tree Trimming

Line Clearance Objectives Line clearance is preventive line maintenance to ensure that the utility's service to its customers is not interrupted as the result of tree interference with conductors or circuit equipment by growing trees. Elements include removal of danger trees and overhangs, trimming to clear the conductors, and clearing transmission right-of-way. Natural tree growth and storm-tossed branches can ground or break distribution and transmission lines. The trimming process is intended to anticipate such a possibility by removing this hazard. Lines are checked and cleared on a planned time cycle. The amount of clearance sought should provide hazard-free operations for at least two years. It should be accomplished while maintaining the health and beauty of the trees involved, the goodwill of property owners, and the safety of the trimming crew.

Factors in Trimming Techniques There are fundamentals essential to safe and competent trimming operations. Primary among these are (1) knowing how to climb and use a rope, (2) knowing how to tie essential knots, (3) a knowledge of tree species—their growth characteristics and wood strength, (4) a knowledge of electrical conductors, (5) a knowledge of alternative trimming methods, (6) knowing how to cut limbs and lower them under full control. Ideally, climbers should be trained to recognize structural problems such as weak crotches and chronic disease symptoms, so that trimming and tree removal decisions result in optimum accomplishment.

Time for Pruning Trees may be pruned at any time of the year and utility line clearance operations are maintained throughout the year. In the past, work often was concentrated into a particular season. However, today, it is recognized that there are compensating values and factors, so that trimming operations run year round except where there are unique, limiting local considerations.

A Basic Set of Pruning Tools

1. One light power chain saw (16-in cutter bar length)
2. One handsaw and scabbard
3. One 12-ft pole saw
4. One 12-ft pole clip or pruner
5. One $\frac{1}{2}$ -in polyester climbing rope (120 ft)
6. Several hand lines ($\frac{1}{4}$ -in polyester)
7. One $\frac{3}{4}$ -in manila bull rope (150 ft)
8. One wooden 24-ft extension ladder
9. One dielectric hard hat for each crew member
10. Tree wound paint in a pot or spray can
11. Belt snaps for handsaw and paint
12. A set of road signs and flags warning of men working in the trees

Some of the pruning tools appear in Figs. 35-1 and 35-2. Other items should be considered, especially when working in residential areas where cleanup is vital: a pair of loppers, a sledge and wedges, brush rake, street broom, and scoop shovel.

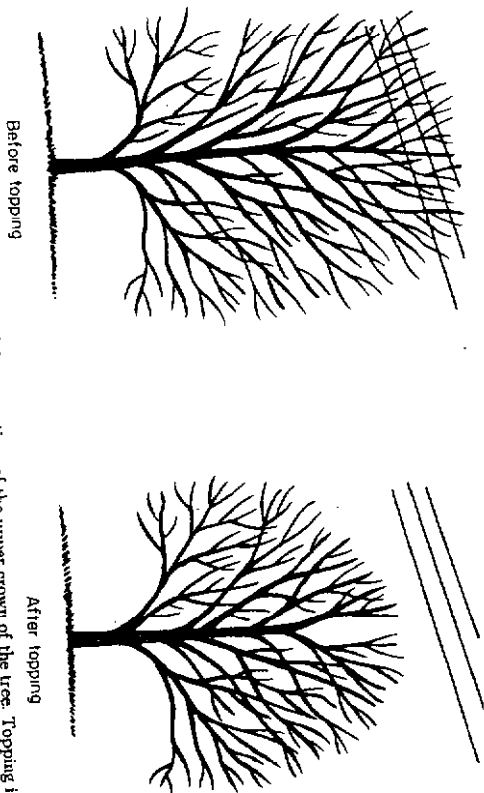


Fig. 35-5 Topping. Topping is cutting back large portions of the upper crown of the tree. Topping is often required when a tree is located directly beneath a line. The main leader or leaders are cut back to a suitable lateral. (The lateral should be at least one-third the diameter of the limb being removed.) Most cuts should be made with a saw; the pole pruner is used only to get some of the high lateral branches. For the sake of appearance and the amount of regrowth, it is best not to remove more than one-fourth of the crown when topping. In certain species—sugar maple for example—removal of too much of the crown will result in the death of the tree.

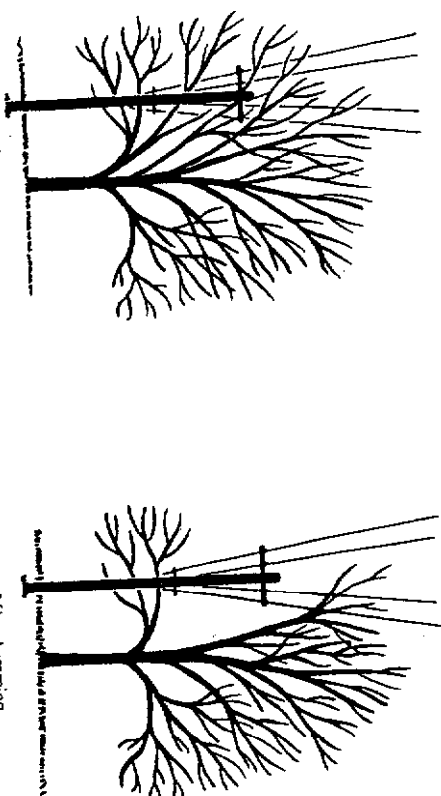


Fig. 35-6 Side Trimming. Side trimming consists of cutting back or removing the side branches that are threatening the conductors. Side trimming is required where trees are growing adjacent to utility lines. Limbs should be removed at a lateral branch. Unsightly notches in the tree should be avoided if possible. Shortening branches above and below the indented area or balancing the opposite side of the crown will usually improve the appearance of the tree. When trimming, remove all dead branches above the wires, since this dead wood could easily break off and cause an interruption.

Lowering Large Limbs Large branches that might cause damage to the line conductors or other property in falling should be carefully lowered with tackle. Figure 35-11 illustrates the manner of lowering a large limb which would otherwise fall directly into the line conductors. Before the branch is sawn off, it is supported with two ropes, one at the butt and the other well out toward the end. The ropes are run through croches in the branches above and secured to the

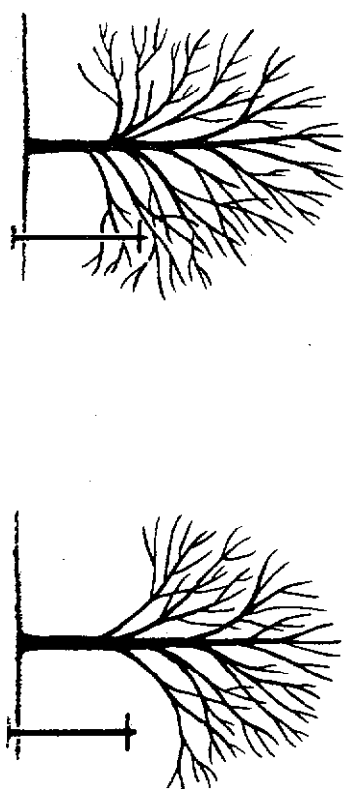


Fig. 35-7 Under Trimming. Under trimming involves removing limbs beneath the tree crown to allow wires to pass below the tree. To preserve the symmetry of the tree, lower limbs on the opposite side of the tree should be removed also. All cuts should be flush to avoid leaving unsightly stubs. The natural shape of the tree is retained in this type of trimming and the tree can continue its normal growth. Overhangs are a hazard, however, when a line passes beneath a tree. Overhangs should be removed in accordance with the species of tree, location, and the general policy of the utility that you work for. When trimming, remove all dead branches above the wires, since this dead wood could easily break off and cause an interruption. Many utilities have a removal program set up for trees that overhang important lines.

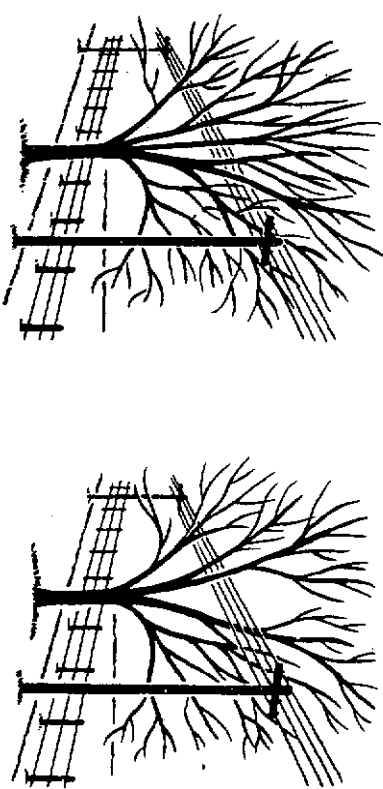


Fig. 35-8 Through Trimming. Through trimming is the removal of branches within the crown to allow lines to pass through the tree. It is best suited for secondaries, street-light circuits, and cables, although it is often used on primary circuits where there is no other way of trimming the tree. Cuts should be made at croches to encourage growth away from the lines.

trunk of the tree. A third rope—known as the guide rope—is fastened to the branch at such a point that it can be used to swing the branch out from over the line conductors. After the sawing is completed, the branch is swung out to clear the line and then gradually lowered by means of the two supporting ropes.

Removing Small Branches In the case of small branches, it is not necessary to make three separate cuts. One cut with the saw close up against the limb while it is held in place, as shown in Fig. 35-12, is all that is necessary. Small branches can also be cut off with a pole pruner. When trees are being trimmed, all dead branches should be pruned out.

Treating the Wounds Every pruning cut larger than 1½ in. in diameter should be sprayed or painted with an asphalt-base tree paint to discourage the entry of insects and disease organisms.

Climbing Equipment For safety and proficiency, climbers should always tie in to a crotch before beginning to trim. The elements involved are a body sling or saddle and a climbing rope. Figure 35-3 illustrates the correct position of the body sling. The climbing rope is a $\frac{1}{2}$ -in polyester rope 120 ft long, attached to the snap of the sling which is in front at the center and then secured by a taut-line hitch. The method of tying the rope with a taut line hitch is covered in detail in Fig. 35-4. This combination permits the climber to move around a tree freely and with safety. Proper use distributes the climber's weight, so he will tire less easily and be able to move onto branches which would not otherwise support his full weight.

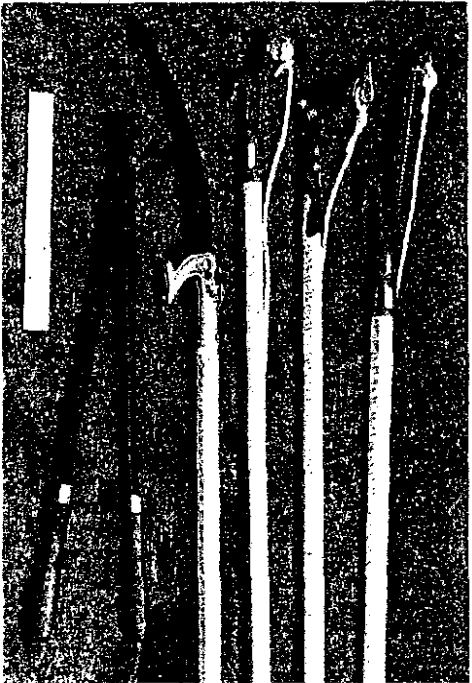


Fig. 35-1 Trimming hand tools. Starting at the top, tools are a center-cut bull clip, a side-cut pole clip, a center-cut pole clip, a pole saw, and a pair of loppers. (Courtesy Asplundh Tree Expert Co.)

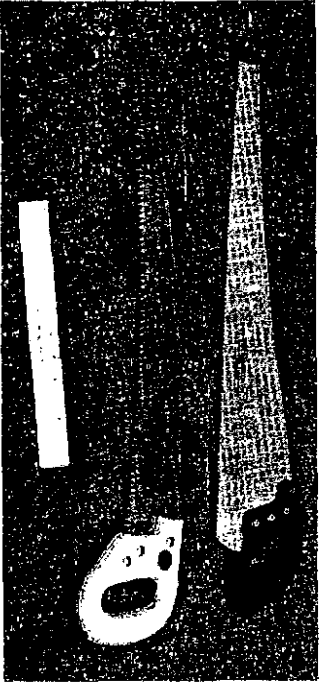


Fig. 35-2 Two types of hand saws. Upper saw cuts on the push, lower saw cuts on the pull. Usage is primarily a matter of personal preference. (Courtesy Asplundh Tree Expert Co.)

Permission No trimming should be started until permission is obtained from the property owner or the state, county, or municipal agency with jurisdiction. Verbal permission is usually satisfactory for routine trimming, but written permission may be advisable for heavy pruning or tree removals. The trimming should then be done under the direction of the person who secured the permission, since he can best interpret any special directions or limitations imposed. To ensure goodwill necessary for future trimming cycles, the work must be professional and the cleanup thorough.

Good and Bad Methods Before providing the details of specific tree trimming techniques it will be useful to review good and bad general methods. Pollarding and shearing or rounding over are undesirable because the visual effect is ugly and contrary to normal free form and because these methods represent uneconomical live clearance. Many small cuts take unnecessary time, create an unhealthy tree condition, and stimulate rapid regrowth back into the conductor. Natural trimming is desirable. In this method, branches are flush-cut at a suitable parent limb back toward the center of the tree. This method is also called drop-croching or lateral trimming. It involves fewer but heavier cuts, usually made with a saw, not a pole pruner. This natural pruning generally permits securing more clearance, so that trimming cycles can be lengthened. In addition, better tree form and value are maintained and regrowth direction can be influenced. Note the following examples in Figs 35-5 through 35-9.



Fig. 35-3 A typical climber's saddle, illustrating the taut-line hitch and figure-eight safety knot. (Courtesy Asplundh Tree Expert Co.)

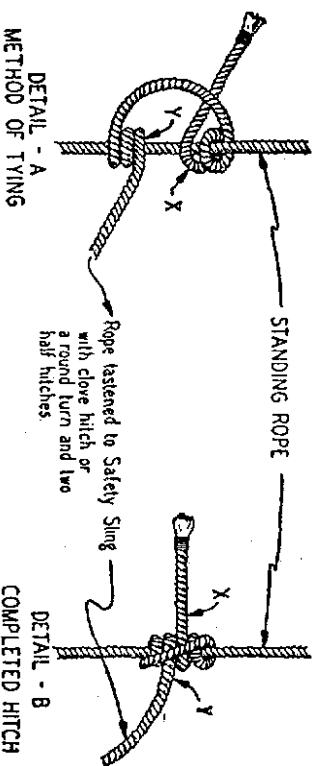
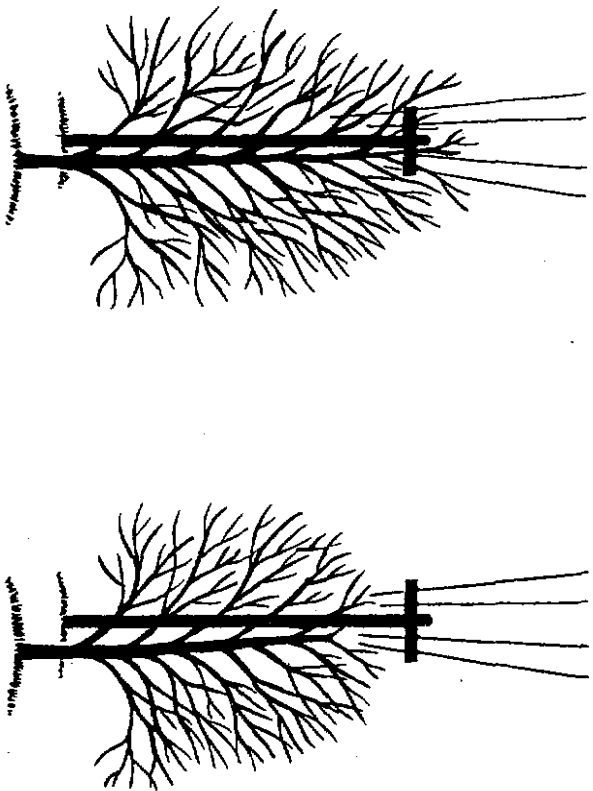


Fig. 35-4 Tying a taut-line hitch to a standing rope. (Courtesy Edison Electric Institute.)

Removing Large Branches The procedure in the removal of a large side limb is shown in Fig. 35-10. The first cut is an undercut 10 to 12 in out from the place where the final flush cut is to be made. This cut should be $\frac{1}{4}$ to $\frac{1}{2}$ the distance through. The second cut is made about 1 to 6 in farther out on the upper side of the branch. The reason for shifting out a few inches is to prevent the bark from being stripped back beyond the point of the final cut when the limb falls. When the bulk of the weight has been removed, the final cut is made flush with the parent limb or trunk in two steps. First an undercut to prevent stripping is made and finally the limb is sawed through from above.



Before Trimming

After Trimming

Fig. 35-9 Natural Trimming. Natural trimming is a method by which branches are cut flush at a suitable parent limb back toward the center of the tree. This method of trimming is sometimes called "drop croching" or lateral trimming. Large branches should be removed to laterals at least one-third the diameter of the branch being removed. Natural trimming is especially adapted to the topping of large trees, where a great deal of wood must be removed. In natural trimming, almost all cuts are made with a saw and very little pole-pruner work is required. This, when finished, results in a natural looking tree, even if a large amount of wood has been removed. Natural trimming is also directional trimming, since it tends to guide the growth of the tree away from the wires. Stubbing or pole-clip clearance, on the other hand, tends to promote rapid sucker growth right back into the conductors. The big factor to remember is that natural clearance does work and that two or three trimming cycles done in this manner will bring about an ideal situation for both the utility and the tree owner. Most shade trees lend themselves easily to this type of trimming. Elm, Norway maple, red oak, red maple, sugar maple, silver and European linden are our most common street trees, and these species react especially well to natural clearance methods.

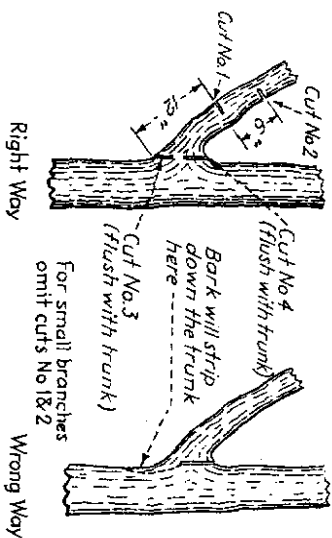
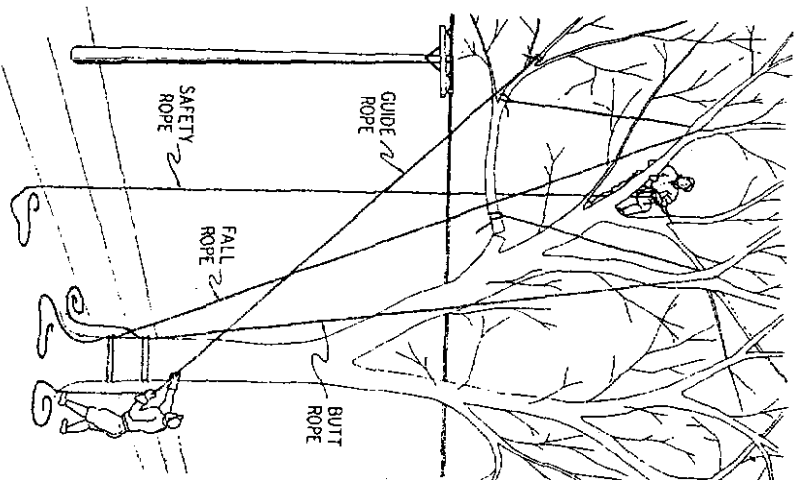


Fig. 35-10 Steps in right and wrong removal of a large side limb. (Courtesy R.E.A.)

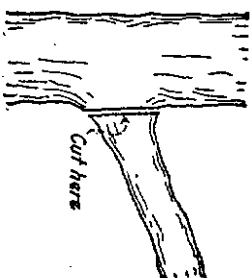
Fig. 35-11 Lowering large or hazardous limb with rope tackle. The two supporting ropes are called butt and fall rope; the third rope is the guide rope. (Courtesy Edison Electric Institute.)



Care should be taken to overlap the area around the cut. The material is applied either by brush from a paint pot snapped to the climber's belt (see Fig. 35-13) or by spraying from a can. There are pole applicators for a spray can that can be used to increase both reach and production. The dark-colored tree paint also serves to make the cuts less noticeable. Brushed tree paint is produced in both summer and winter grades to provide for flowability in extreme cold. Paint is generally formulated to spray under all weather conditions. Recent field research suggests that on many tree species the addition of a growth inhibitor—such as 1 percent naphthaleneacetic acid, ethyl ester—to the tree paint will significantly reduce resprouting at the treated cut. Utilization can make second-cycle trimming more economical because fewer cuts are required and there is less brush to manage.

Brush Disposal All brush and wood trimmed in line clearance operations must be disposed of in such a way as to maintain the goodwill of property owners. In residential trimming, it is

Fig. 35-12 How a small branch can be removed with a single cut.



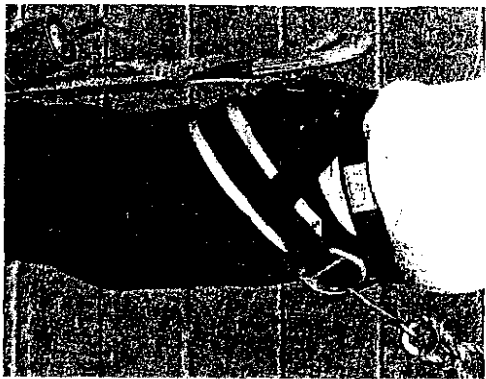


Fig. 35-13 A typical climber's saddle with saw scabbard and tree paint pot snapped to position.

usually most economical to chip the brush. Note Fig. 35-14. Public relations generally requires that the work area be raked or swept up. Material suitable for fireplace usage should be cut to size and neatly stacked. It should first be offered to the property owner, and if he rejects it, may be left available for the general public. However, some situations may require that the wood be hauled away and dumped. On right-of-way clearance or when trimming in remote areas, it is sometimes possible to pile brush and leave it as game cover. Generally, burning is no longer permitted because of concern about smoke and fly ash.

Power Equipment Technology responds to operational needs and there are now various pieces of specialized equipment designed to solve special problems or to increase productivity.

Trim-Lift Whenever a truck can drive, an aerial device can be effectively used to position a man for trimming, thus saving the trouble of climbing. The mechanism involves two connected booms, with a work platform or bucket at one end, mounted on a truck chassis. The upper boom is supported by the lower boom through the use of cables. A hydraulic power system runs off the truck engine and lifts the booms, operates the tools, and lifts the dump hodies to discharge chips and other materials gathered in trimming. Note Figs. 35-15 and 35-16. Mechanical outriggers are

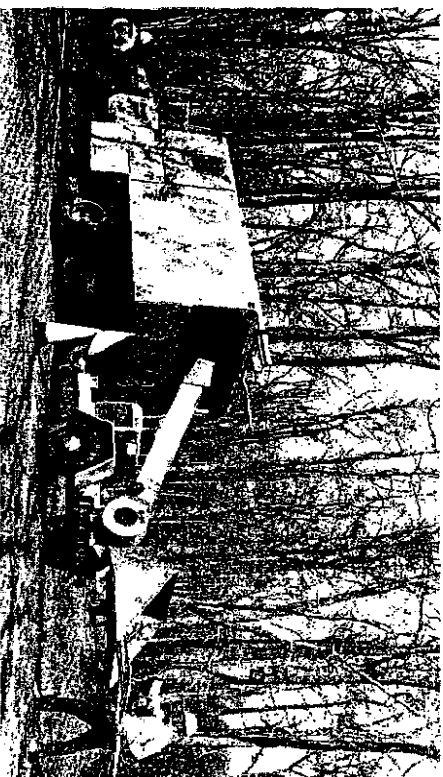


Fig. 35-14 A manual climbing crew in operation. Note the groundman chipping brush behind the climber. The chute of the chipper directs the chips into the back of the dump van. (Courtesy Asplundh Tree Expert Co.)



Fig. 35-15 A trim-lift and chipper in use by crew to trim trees and dispose of brush. (Courtesy Asplundh Tree Expert Co.)

used to stabilize the unit during operation. Generally, the booms and the work platform are fully insulated to protect the operator from shock and the truck body from becoming energized if the boom or platform should come in contact with a conductor.

Tree Crane This type of aerial device is used primarily for taking down trees too tall to reach with a trim-lift. See Fig. 35-17. The equipment utilizes a boom that telescopes and a climber working from a "saddle" and a rope swung from the boom tip.

Power Tools Chain and circular blade saws are powered by compact gasoline engines and designed in a variety of sizes and weights to adapt to the many conditions encountered. From take-downs to tree trimming to brush cutting. (See Figs. 35-18 and 35-19.) Noise levels generally dictate hearing protection for the operator.

A variety of cutting tools can be hydraulically powered or air-operated by a system connected with the bucket of a trim-lift. These include pole chain saws, circular saws, and limb loppers illustrated in Fig. 35-20. Some situations, such as hospital areas, may require the use of electrically powered tools operated by a portable gasoline generator. Power equipment requires systematic inspection and preventive maintenance to ensure crew safety and efficiency.

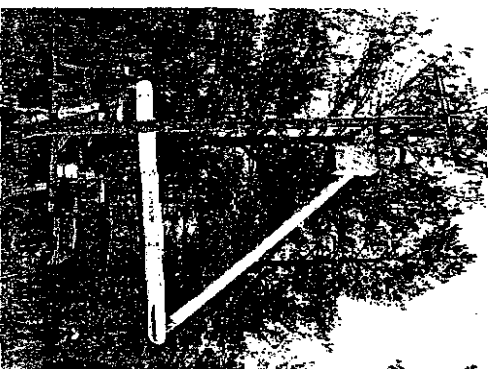


Fig. 35-16 A specialized right-of-way trim-lift with the boom mechanism mounted on a diesel-powered, four-wheel-drive vehicle. (Courtesy Asplundh Tree Expert Co.)

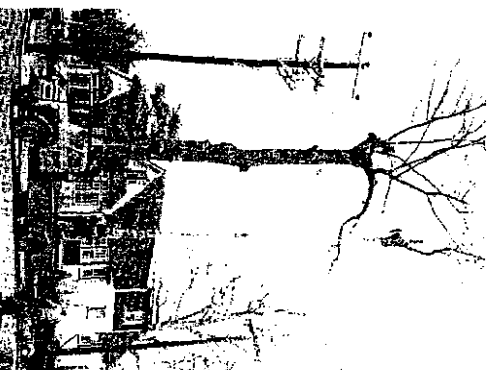


Fig. 35-17 A tree crane in operation. (Courtesy Asplundh Tree Expert Co.)

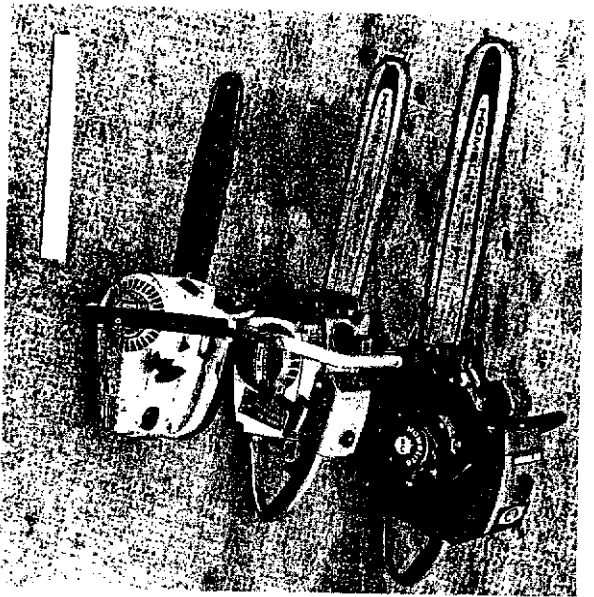


Fig. 35-18 Several gasoline-powered chain saws, each a size and weight to be used easily by one man. It is unlikely that the model at the top of the picture would be used off the ground. (Courtesy Asplundh Tree Expert Co.)

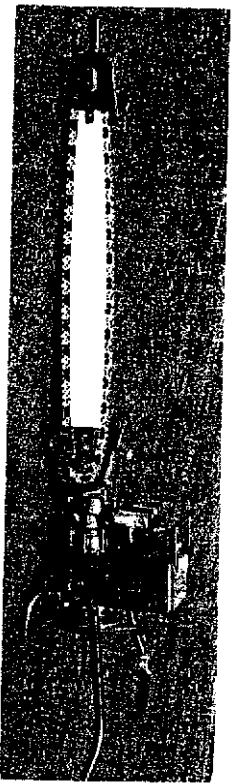


Fig. 35-19 Large portable power-driven saw. (Courtesy Asplundh Clipper Co.)

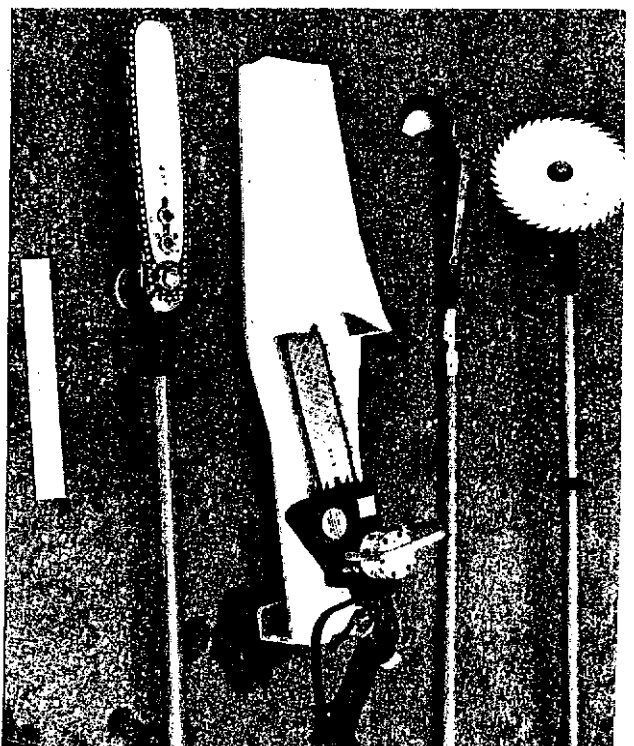


Fig. 35-20 Hydraulic tools of a type used from a trim-tilt bucket. (Courtesy Asplundh Tree Expert Co.)

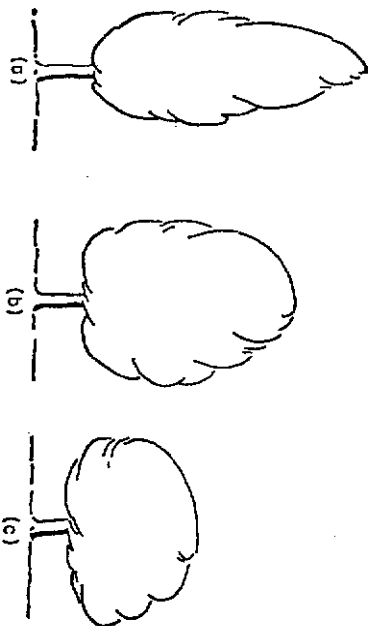


Fig. 35-21 Tree form types that are basic in planning and maintaining clearance for overhead lines. (a) Upright; (b) spreading; (c) horizontal.

Table 35-1 Characteristics of Various Trees*

Species (common name)	Avg. annual terminal growth,† ft	Approx. mature height, ft	Compar- ative wood strength values (green),‡ lb per sq in.	Suggestions
Upright growth form:				
Cottonwood (Carolinian poplar)§	4.30	85	5,300	Can do any type of trimming. Avoid overbuilding. Can top.
Elm (American)	2.14	85	7,200	Avoid overbuilding. Can top.
Gum (sweet)	0.66	100	6,800	Slow growing. Best underbuilt.
Hickory	0.96	65	11,000	Best side trimmed or underbuilt.
Kentucky coffee tree	0.90	80	Unknown	Top side, or under trim. Slow-growing tough wood.
Locust (honey)	1.50	80	10,200	Hard, strong wood. Can be topped. Best underbuilt.
Maple (silver)	2.14	75	5,800	Avoid if possible. Should be underbuilt.
Oak (pin).....	2.00	70	8,300	Vigorous sucker growth when topped too heavily. Do not top.
Poplar (Lombardy)§	3.63	80	Unknown	Strong hardwood. Do not top.
Sycamore (American)	1.50	75	6,500	Avoid or remove. Soft, brashy wood.
Spreading growth form:				
Basswood	1.50	75	5,000	Vigorous sucker growth when topped. Best to underbuilt.
Beech (American)	1.85	60	8,600	Soft, weak wood. Overbuilt.
Birch (white)	1.80	50	6,400	Does not stand severe topping.
Buckeye (horse chestnut)	1.00	60	4,800	Side or under trim.
Cherry (black)	1.00	60	8,000	Do not top. Avoid or trim lightly.
Hackberry	1.00	50	6,500	Top or side trim. Soft, weak wood.
Locust (black)§	1.30	60	13,800	Do not top heavily. Underbuilt.
Maple (red)	1.50	75	7,700	Old trees.
Maple (sugar)	1.50	75	9,400	Top or side trim on older trees.
Oak (live)	1.11	60	11,900	Vigorous sucker growth when topped.
Oak (red)	1.50	75	6,900	Side or under trim old trees.
Oak (white)	0.75	75	8,300	Do not top too heavily. Side or under trim.
Sycamore (oriental)	1.80	60	Unknown	Can be topped. Vigorous sucker growth.
Walnut (black)	1.00	80	9,500	May die back when topped heavily. Underbuilt old trees.
Horizontal growth form:				
Box elder§	2.15	50	Unknown	Vigorous sucker growth. Use good pole heights. Top or side trim.
Dogwood	0.30	30	8,800	Slow growing, overbuilt.
Maple (Norway)	1.20	50	Unknown	Overbuilt, top trim.
Orange oranges	1.40	45	13,700	Thorny, fast growing. Can be topped.
Willow (black)§	1.67	50	3,800	Brashy, fast-growing wood. Avoid if possible.

Note: All species of conifers with exception of white and red cedar and hemlock do not lend themselves well to topping.

† Reprinted with permission from "Time Clearing Manual," Publication K-10 of The Edison Electric Institute.

‡ Approximate normal average rates for Central Western states—subject to variation due to soil, moisture and site conditions. As pruning stimulates growth, these values should be approximately tripled to arrive at first year growth rate of topped trees.

§ U.S. Government standard test for modulus of rupture, static bending of a simple beam (Technical Bulletin No. 479).

¶ Remove if possible.

Table 35-2 Tree Trimming Clearances
(in feet)

	Secondary, 100-600 volts	Primary, 2400- 4800 volts	Primary, 7200- 13,800 volts
Topping			
Fast growers	6	8	9
Slow growers	4	6	7
Side			
Fast growers	4	6	8
Slow growers	2	4	6
Overhang			
Fast growers	4	8	12*
Slow growers	2	6	12*

SOURCE: Asplundh Tree Expert Co.
* Remove if possible.

Poisonous Plants When he is trimming trees and removing brush, there is always the possibility that a fireman may encounter plants which may cause skin poisoning. These include the following:

Poison Ivy This plant sometimes climbs trees and poles. It is also a crawling plant. Poison ivy has broad and glossy leaves that always grow in clusters of three leaflets, two branching from the stem 1 in or less below the center one.

Poison Oak A low-growing erect plant, poison oak never climbs. The leaves are broad but not always glossy and occur in clusters of three. The dark-green leaves are permanently and very heavily hairy on the undersurface.

Poison Sumac This shrub or small tree may grow to a height of 20 ft. Its smooth, glossy leaves are in the form of 7 to 13 oblong leaflets (always an odd number). Poison sumac grows in swamps and low areas.

The poisoning from these plants is caused by an oily substance which gets on a person's skin. The poison can be conveyed by smoke, insects, clothing, and direct contact, and it is more likely to occur when the skin is covered with perspiration. No one should ever consider himself immune to these poisons, even after having had an attack.

If a worker suspects that he has been exposed to these plants or their oil, he should wash exposed areas of skin with warm water and ordinary brown laundry soap. Another way to prevent poisoning is to wash the exposed skin in rubbing alcohol and then rinse in clear water and dry the skin. No brush should be used, because it would irritate the skin.

Natural Tree Forms All trees can be classified as one of three forms:

1. Upright
2. Spreading
3. Horizontal

The tree-form types are shown in Fig. 35-21. As far as possible trees should be trimmed to preserve their natural shape. Table 35-1 lists the trees according to their form and also indicates their annual growth in feet as well as the comparative strength of the wood. Table 35-2 itemizes suggested trimming clearances for various voltages.